

Astrophysics Projects Division



Physics of the Cosmos Program



Cosmic Origins Program

How COR Technology Priorities Are Established

Cosmic Dawn SIG Meeting at AAS

January 3, 2017

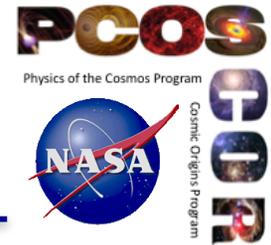
Thai Pham

Harley Thronson

We Will Cover ...

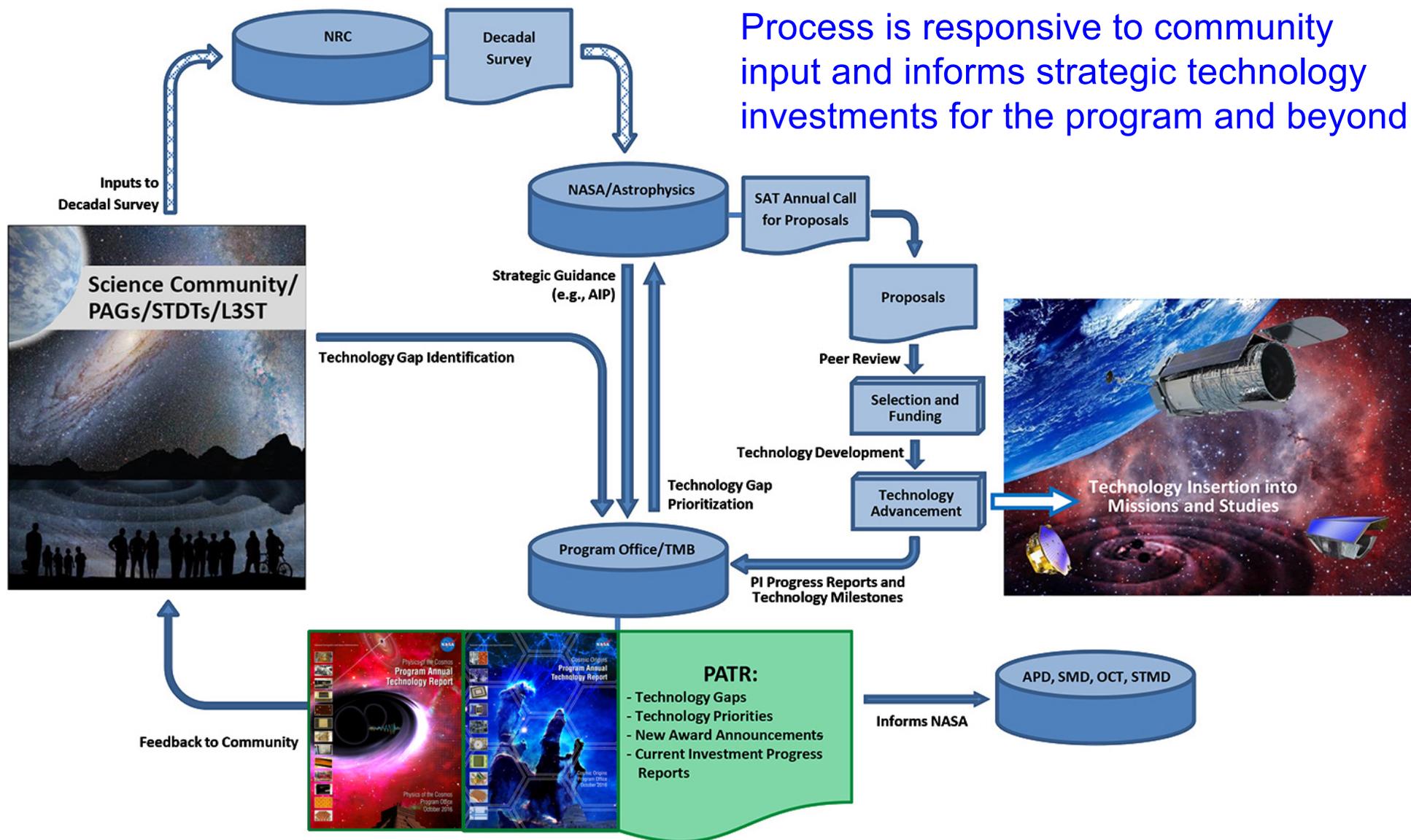
- Overview of COR strategic technology development process
- Technology gaps identification
- Prioritization process and 2016 results
- Current strategic technology portfolio
- How you can contribute and engage

NASA Astrophysics Funds All Levels of Technology Maturity



- **Astrophysics Research and Analysis (APRA) program** solicits basic research proposals relevant to NASA's astronomy and astrophysics programs, from basic principles through flight missions (Technology Readiness Level, TRL, 1 through 3 up to 9). Suborbital investigations (balloons, sounding rockets) are encouraged. Typically 4 or 5 yrs duration awards.
- **Strategic Astrophysics Technology (SAT) program** matures key technologies that address the needs of a strategic mission, taking them from proof of concept through component/breadboard validation in relevant environment (TRL 3 through 5). Typically 2 or 3 years duration awards.
- **Flight projects** address the final maturation stages (TRL 6 through 9) proving the technology's flight-worthiness for a mission-specific application.

Strategic Technology Development Process



Program Annual Technology Report (PATR)

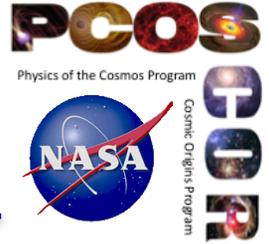


The PATR is an annual report that summarizes the Program's technology development activities for the prior year.

- Provides **overview** of the Program and its technology development activities.
- Gives **status** of the Program's strategic and targeted technology development for the prior year and announces the new SAT award selections.
- Presents the current set of technology gaps received from the community and study teams, divided into **priority** tiers to inform the SAT solicitations and selection decisions
- **Updated annually** and released in October to support annual technology development planning.

COR PATR can be downloaded from <https://cor.gsfc.nasa.gov/technology/>
 PCOS PATR can be downloaded from <https://pcos.gsfc.nasa.gov/technology/>

Objectives and Purposes of Technology Gap Prioritization



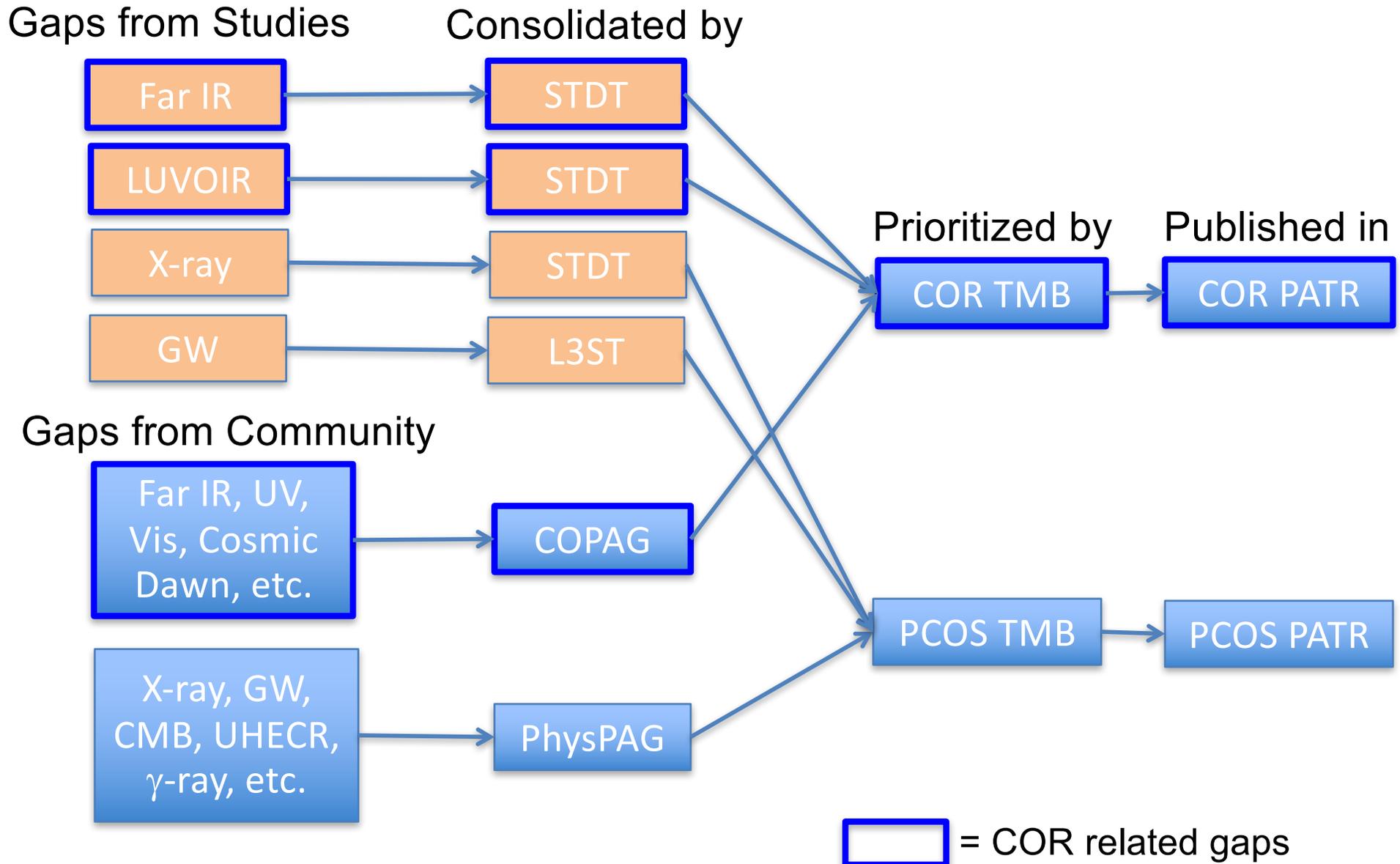
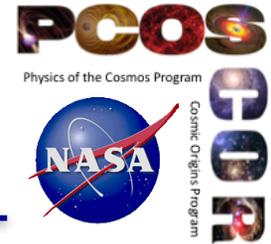
- **Objectives**

- Identify **technology gaps** applicable and relevant to Program strategic objectives as described in the AIP, Roadmap, and Decadal Survey
- Rank these **technology gaps** with respect to strategic alignment, benefits and impacts, cross-cutting capabilities, and urgency; then recommend investment priorities

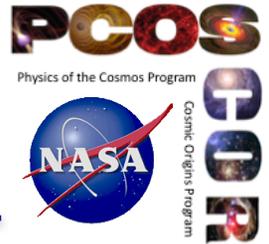
- **Purposes**

- Inform the **SAT solicitation** and other NASA technology development programs (APRA, SBIR, and other OCT and STMD activities)
- Inform technology developers of Program technology gaps to help **focus efforts**
- Inform **selection** of technology awards to be aligned with Program goals and science objectives
- Improve **transparency and relevance** of Program technology investments
- Inform the **community and engage it** in our technology development process
- Leverage **technology** investments of external organizations by defining our strategic technology gaps and identifying NASA as a potential customer
- Inform the **Astrophysics Division** of the relative priorities of the technology gaps submitted by the study teams for future planning purposes

New This Year – Additional Gap Inputs From STDTs and L3ST



Overview of Technology Gap Identification and Prioritization Process



- **The community identifies technology gaps**
 - by working with the Program Analysis Group (PAG) or through direct individual submission to the Program Office (annual cutoff June 1)
- **Study teams submit their gaps by end of June**
- **The TMB reviews and prioritizes the gaps in July**
 - TMB membership includes senior members of NASA HQ Astrophysics Division, the Program Office, Aerospace, and as required, independent subject matter experts
 - Technology gaps prioritization is based on a published set of criteria that addresses **strategic alignment, benefits and impacts, scope of applicability, and urgency**
- **The technology gaps and resulting priorities are published in the PATR**

Community Technology Gap Submission

A technology gap can be identified by anyone and provided to the PO for prioritization in either of two ways:

- Provide it to the **appropriate SIG** of the COPAG for consolidation and submission to the COR Program Office, or
- Submit it **directly** to the COR Program Office (thai.pham@nasa.gov)
- Submissions will be forwarded to the COPAG Executive Committee for help with consolidation (combining similar, overlapping, or missing gaps) and editing if needed for accuracy and completeness
- Submissions relevant to any of the study teams will be forwarded to them for consideration to be added to their gap list.

Technology Gap Form

1. **Name** of technology capability gap
2. **Description** of technology capability needed
3. Assessment of the relevant **current state-of-the-art** technologies and those that could close this gap, including their Technology Readiness Levels (**TRLs**) and justification reference
4. Description of quantitative/ measurable **performance goals and objectives** to fill this capability gap
5. **Scientific, engineering, and/or programmatic benefits** of achieving this capability (filling the “gap”)
6. **Potential applications** and relevant mission(s)
7. **Urgency** to mature this gap

COR Program Technology Capability Gap Input Form		
<u>Technology Capability Gap Name:</u>		<u>Date Submitted:</u>
<u>Submitter Name:</u>	<u>Organization:</u>	
<u>Telephone:</u>	<u>Email Address:</u>	
PATR Prioritization Information (see accompanying instructions)		
<u>Brief Description of the Technology Capability Needed (100 – 150 words):</u>		
<u>Assessment of the current State-of-the-Art (SOTA) and references justifying TRLs quoted at right (100 – 150 words):</u>	<u>Current TRL of SOTA:</u>	
	<u>Current TRL of Full Solution:</u>	
<u>Technical Goals and Objectives to Fill the Capability Gap:</u>		
<u>Scientific, Engineering and/or Programmatic Benefits (100 – 150 words):</u>		
<u>Applications and Potential Relevant Missions for COR, PCOS, and ExEP:</u>		
<u>Urgency (time to estimated launch date for enabled/enhanced missions or other schedule driver):</u>		

Suggestions for Technology Gap Inputs

- Focus on technology capability gaps associated with **missions prioritized** in the Astrophysics Implementation Plan, Roadmap, or Decadal Survey
- Submit technology gaps that are directly **applicable to Program objectives**.
 - Don't include gaps that are not in our charter such as technologies associated with launch vehicle, rover, avionics, spacecraft systems, etc.
- **Don't include** gaps that do not require technology development, that are not well defined, that are redundant (duplicate, similar, or subsets of other gaps), or are at TRL 6 or higher
- Inputs should be submitted as technology **capability gaps** between the current state-of-the-art and what's needed to achieve the science objective targeted, **not specific implementations**
- Inputs **should not endorse or advertise** for any organization, mission, or person
- Inputs **should not contain proprietary or ITAR-sensitive** information

Prioritization Criteria Address...

- **Strategic Alignment:** How well does the technology align with the science and/or programmatic priorities of the Astrophysics Implementation Plan (AIP) or current programmatic assessment?
- **Benefits and Impacts:** How much impact does the technology have on COR science related mission(s)? To what degree does the technology enable and/or enhance achievable science objectives, reduce cost, and/or reduce mission risks?
- **Scope of Applicability:** How cross-cutting is the technology? How many Astrophysics programs and/or mission concepts could it benefit?
- **Urgency:** When are launches and/or other schedule drivers of missions enhanced or enabled by this technology anticipated?

COR 2016 Technology Gaps Prioritization

	COR Capability Gaps	Science	Tech
1	Large-format, low-noise and ultralow noise Far-IR direct detectors	FIR	Detector
	Heterodyne Far-IR detector arrays and related technologies	FIR	Detector
	Large cryogenic optics for the Far-IR	FIR	Optics
	High-performance, sub-Kelvin coolers	FIR	Cooler
	Compact, integrated spectrometers for 100 to 1000 μm	FIR	Detector
	Large-format, high-sensitivity, high-dynamic-range UV/FUV detectors	UV/FUV	Detector
	High-efficiency UV multi-object spectrometers	UV	Detector
	Band-shaping and dichroic filters for the UV/Vis	UV/Vis	Optics
	Lightweight large-aperture high-performance telescope mirror systems	UV/Vis/IR	Optics
2	Advanced Cryocoolers	FIR	Cooler
	Mid-IR spectral coronagraph	Mid-IR	Optics
	High-performance spectral dispersion component/device	UV/Vis/IR, FIR	Optics
	High-reflectivity mirror coatings for UV/Vis/NIR	UV/Vis/IR	Coating
	High-contrast segmented aperture coronagraphy	UV/Vis/IR	Optics
	Ultra-stable opto-mechanical systems	UV/Vis/IR	Telescope
	Very-large-format, high-QE, low-noise, radiation-tolerant detectors for UV/Vis/NIR	UV/Vis/IR	Detector
3	Wide-bandwidth, high-spectral-dynamic-range receiving system	Radio Freq	Detector
	FIR interferometry	FIR	Detector

See COR PATR for more information about these gaps

Current COR SAT Portfolio

Funding Source	Technology Development Title	Principal Investigator	Org	Start Year, Duration	Science Area	Tech Area
SAT2011	Ultraviolet coatings, materials and processes for advanced telescope optics	Kunjithapatham Balasubramanian	JPL	FY2013, 3 years	UV	Optical Coating
SAT2011	Kinetic Inductance Detector Imaging Arrays for Far-Infrared Astrophysics	Jonas Zmuidzinas	JPL	FY2013, 3 years	Far-IR	Detector
SAT2012	A Far-Infrared Heterodyne Array Receiver for CII and OI Mapping	Imran Mehdi	JPL	FY2014, 3 years	Far-IR	Detectors
SAT2012	Deployment of Digital Micromirror Device (DMD) Arrays For Use In Future Space Missions	Zoran Ninkov	RIT	FY2014, 2 years	UV	Detector
SAT2012 SAT2010	Advanced Mirror Technology Development Phase 2	Phil Stahl	MSFC	FY2014, 3 years	UVOIR	Optics
SAT2014	Raising the Technology Readiness Level of 4.7-THz local oscillators	Qing Hu	MIT	FY2016, 3 years	Far-IR	Detector
SAT2014 SAT2010	Development of Large Area (100x100 mm) photon counting UV detectors	John Vallergera	UCB	FY2016, 2 years	UV	Detector
SAT2014	Building a Better ALD - use of Plasma Enhanced ALD to Construct Efficient Interference Filters for the FUV	Paul Scowen	ASU	FY2016, 3 years	UV	Optical Coating
SAT2014 SAT2011	Advanced FUVUV/Visible Photon Counting and Ultralow Noise Detectors	Shouleh Nikzad	JPL	FY2016, 3 years	UVOIR	Detector
SAT2014	Ultra-Stable Structure: Development and Characterization Using Spatial Dynamic Metrology	Babak Saif	GSFC	FY2016, 4 years	UVOIR	Stable Structure
SAT2015	High-Efficiency Continuous Cooling for Cryogenic Instruments and sub-Kelvin Detectors	James Tuttle	GSFC	FY2017, 3 years	Far-IR	Cooling System
SAT2015 SAT2012 SAT2010	Predictive Thermal Control Technology for Stable Telescope	Phil Stahl	MSFC	FY2017, 3 years	UVOIR	Optics

Takeaways

- COR Program Office solicits community input on technology gaps throughout the year
 - **Submit gaps by June 1** for this year's prioritization
- Technology gap priorities are published each October in the PATR
 - **Consult the PATR** to learn what strategic technologies are needed by the COR program
- Propose to SAT through NSPIRES to ROSES Program Element D.8
 - **Notices of Intent to propose are due January 20, 2017**
 - **Proposals are due March 17, 2017**

Thank You For Listening

The Strategic Astrophysics Technology (SAT) Program Is Developing Technologies for Future Large Missions

Cosmic Origins (COR) and Physics of the Cosmos (PCOS) Programs help mature technologies across the mid-TRL gap to enable and enhance future astrophysics missions addressing the science questions:

How Did We Get Here? How Does the Universe Work?

The SAT Program supports technology development for strategic missions observing throughout the electromagnetic spectrum, as well as gravitational waves

The Cosmic Origins and Physics of the Cosmos Programs

The COR and PCOS Programs work to answer two fundamental questions: "How did life become complex and evolve to produce the galaxies, stars, and planets we see today?" (COR) and "How does the universe work, starting with the basic building blocks of our existence – matter, energy, space, and time?" (PCOS)

Current and future missions and platforms pursuing PCOS and COR objectives:
COR: Hubble Space Telescope, Galileo Space Telescope, SOFIA, and James Webb Space Telescope.
PCOS: Chandra X-ray Observatory, Fermi Gamma-ray Space Telescope, XMM-Newton, USA Pathfinder (SPFS), Swift, Athena, and IXO/STO.

Large inter-agency teams (led by Science and Technology Definition Teams (STDTs) include the Origins Space Telescope (OST), currently the IXO Surveyor, Large Ultraviolet/Optical (LVOOR) Surveyor, and X-Ray Surveyor (XRS), recently selected for the STDT (see STDT) working a priority STDT opportunity to the USA 12 gravitational-wave observatory. A future STDT is currently being formed to study the Cosmic Microwave Background in the pursuit of the European Space Agency (ESA).

The Cosmic Origins and Physics of the Cosmos Program Offices

The COR and PCOS Program Offices oversee the COR and PCOS SAT Program for NASA HQ and Astrophysics Division, which mature technologies to enable and enhance strategic astrophysics missions. The Astrophysics Division provides strategic guidance based on:

- "New Worlds, New Horizons in Astronomy and Astrophysics" 2013 Decadal Survey
- "Astrophysics in the Next Decade" Plan, Study, and
- "Enabling Decadal, Decade Missions," the Astrophysics Roadmap.

The Programs solicit technology ideas throughout the year, and annually prioritize those received from the general community by June 1 and from the STDTs and LST by June 20. The open and solicited are published in the COR and PCOS Program Annual Technology Reports (PATRs), which also provide an overview and status reports of the Programs and their technology development activities for the year prior, and the STDTs and LST submit their final reports to the Program Offices forward any ideas to their gaps to the Study Teams so they can consider implementing them in the next version of their gap.

SAT Solicitations and Funding

Invited by the gap and funding requests, the SAT Program solicits technology proposals through the Response Proposals Opportunities in Space and Earth Sciences (PROSE) announcement of opportunity. SAT projects mature technologies at mid-range Technology Readiness Levels (TRL 2-5), in preparation for eventual infusion into instruments, missions, and studies pursuing COR and PCOS science objectives. To date, 17 COR and 64 PCOS SAT projects were received, with 14 COR and 26 PCOS projects selected.

Sub-mm/Far-IR to Far-UV

Technological breakthroughs in detection, optics, and coatings being pursued by SAT projects promise to make future missions more the broad range of electromagnetic wavelengths. These missions include WFIRST in the coming decade and looking further into the future, possibly the COR or Athena Probe, and a LVOOR Surveyor.

X Rays

With the high energy and thus short wavelengths of X rays, developing and making X-ray optics, detectors, and related electronics is very challenging. Coatings and grating optics require advanced material properties and stability, ultraviolet, and detection readout. Addressing high-resolution efficiency and resolution with low noise. Technologies developed in this area are intended to enable and enhance the performance of Athena in the approaching decade, and looking further into the future, possibly the IXO Surveyor.

Gravitational Waves

Following LIGO's dramatic February 2016 announcement of the first-ever detection of gravitational waves, a new window has opened to observe some of the most extreme phenomena in the universe, such as rapidly spinning massive black holes. The next future concept for detecting gravitational waves is based on a new type of detector, called the space-based Einstein Telescope (ET) or Cosmic Explorer (CE), which will be located in space. The ET/CE will be a major step towards the realization of a new type of detector, which will enable the observation of some of the most extreme phenomena in the universe. Such an instrument requires technologies in a range of technologies, which will require a major effort, termed to launch by NASA in a Ground-based Telescope Surveyor 25-30 years from now.

Astronomy and Astrophysics – from Ancient Times to the Future

This poster takes us on a journey from ancient astronomical observations, conducted by the Mesopotamians of Babylonia, through NASA's Great Observatories to future missions in development and planning. At the center are two large mission concepts under study or conceptualized for the 2030s Decadal Survey. Background images are related to the HST, LIGO and programs in 2015, and related astrophysics research into the Cosmic Web, COR 2-mission possibilities, X rays, gravitational waves, and dark, submillimeter optics and gravitational waves have expanding black holes, symbolized by a spiral, reference the NASA Astrophysics Division's 30-year Strategy Roadmap. The Roadmap and the 2013 Decadal Survey form the basis for the large mission concepts under study. The PCOS and COR Program Offices shepherd technology developments to enable these missions.

How You Can Support Future Strategic COR and PCOS Missions

Submit by June 1, 2012, Technology Class for COR and PCOS. Pre-submission by July 2017. Pre-submission by 3/15/2012. Pre-submission by 3/15/2012.

COR and PCOS Program Annual Technology Reports (PATRs)

- Supports Program technology development activities for the prior year
- Provides an overview of the Programs and their technology development activities
- Report the status of the Programs' strategic and ongoing technology development
- Document the technology capability gaps identified from the community
- Provide a prioritized list of technology gaps for the coming year to address Program technology planning and SAT proposal calls and selection decisions

Poster Authors and Program Technologists:

Thai Pham, thai.pham@nasa.gov
 Harley Thronson, harley.a.thronson@nasa.gov

SAT Points of Contact and Program Scientists:

COR: Maria Perez, maria.perez@nasa.gov
 PCOS: Ato Sambra, ato.sambra@nasa.gov

For more information, visit the COR Program website at cor.gsfc.nasa.gov and the PCOS website at pcos.gsfc.nasa.gov

Thursday Poster Session 238.01

Harley Thronson
harley.a.thronson@nasa.gov

Thai Pham
thai.pham@nasa.gov